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Takeda

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[45] **Date of Patent: Aug. 22, 2000**

[54] **CUTTING APPARATUS EQUIPPED WITH TOOL VARIABLY PRESSED AGAINST WORK DEPENDING UPON WORKING DISTANCE**

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[73] Assignee: **Yamaha Corporation**, Japan

[21] Appl. No.: **09/188,499**

[22] Filed: **Nov. 9, 1998**

Related U.S. Application Data

[62] Division of application No. 08/878,480, Jun. 19, 1997, Pat. No. 5,860,349, which is a continuation of application No. 08/524,047, Sep. 6, 1995, abandoned.

[30] **Foreign Application Priority Data**

Sep. 9, 1994 [JP] Japan 6-216074

[51] **Int. Cl.**[7] **B26D 3/08**

[52] **U.S. Cl.** **83/881**; 83/886; 83/887; 83/76.6

[58] **Field of Search** 83/881, 880, 884, 83/886, 887, 76.1, 76.6, 76.7, 76.8, 13, 56; 225/96.5, 96, 1, 3, 4; 125/13.01, 29

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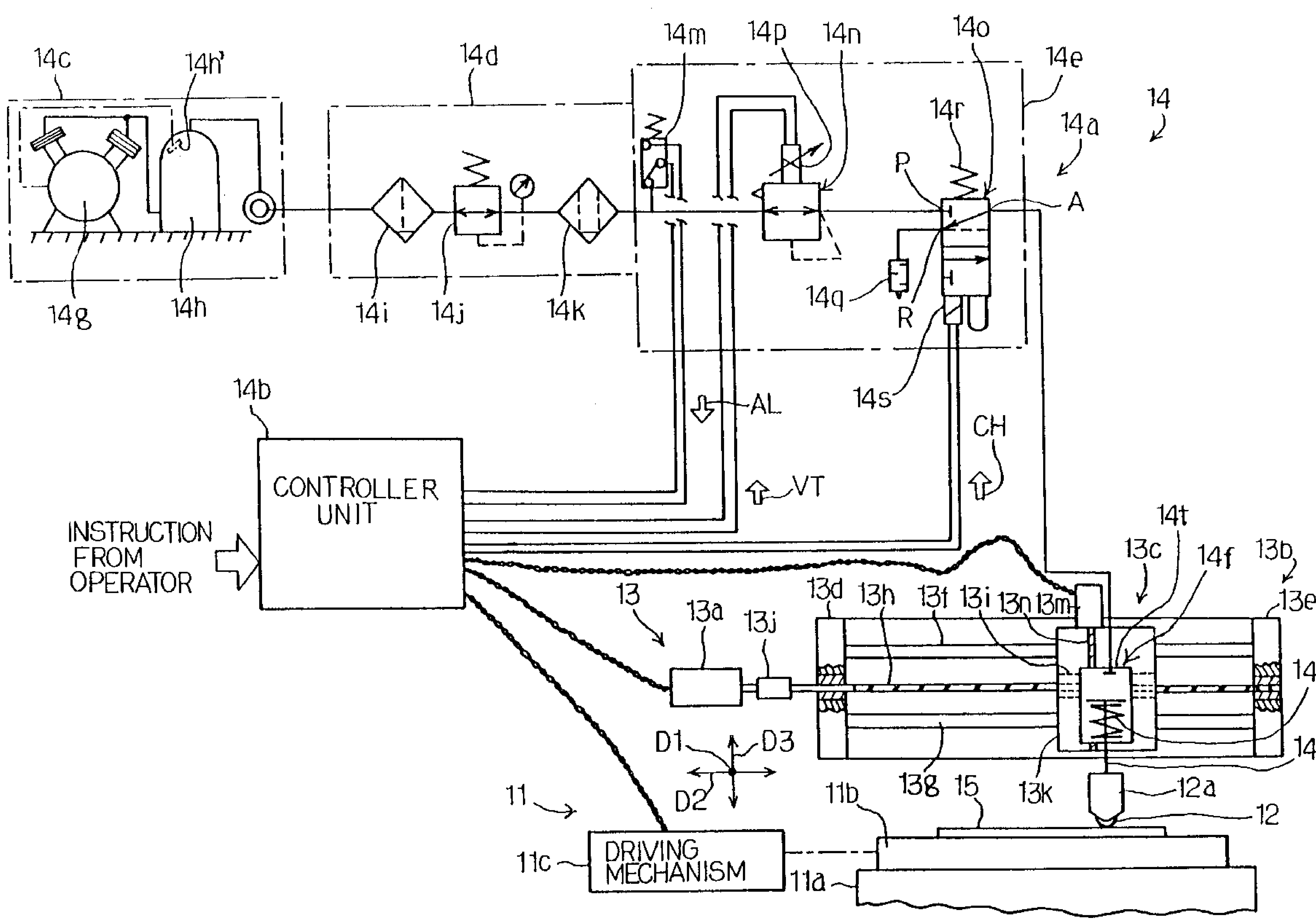
[57] **ABSTRACT**

A cutting apparatus presses a wheel cutter against a ceramic plate for cutting it along a cutting line, and a controlling unit determines the total cutting length so as to increase the pressure against the ceramic plate together with the total cutting length, thereby keeping the depth of cutting trail constant.

8 Claims, 8 Drawing Sheets



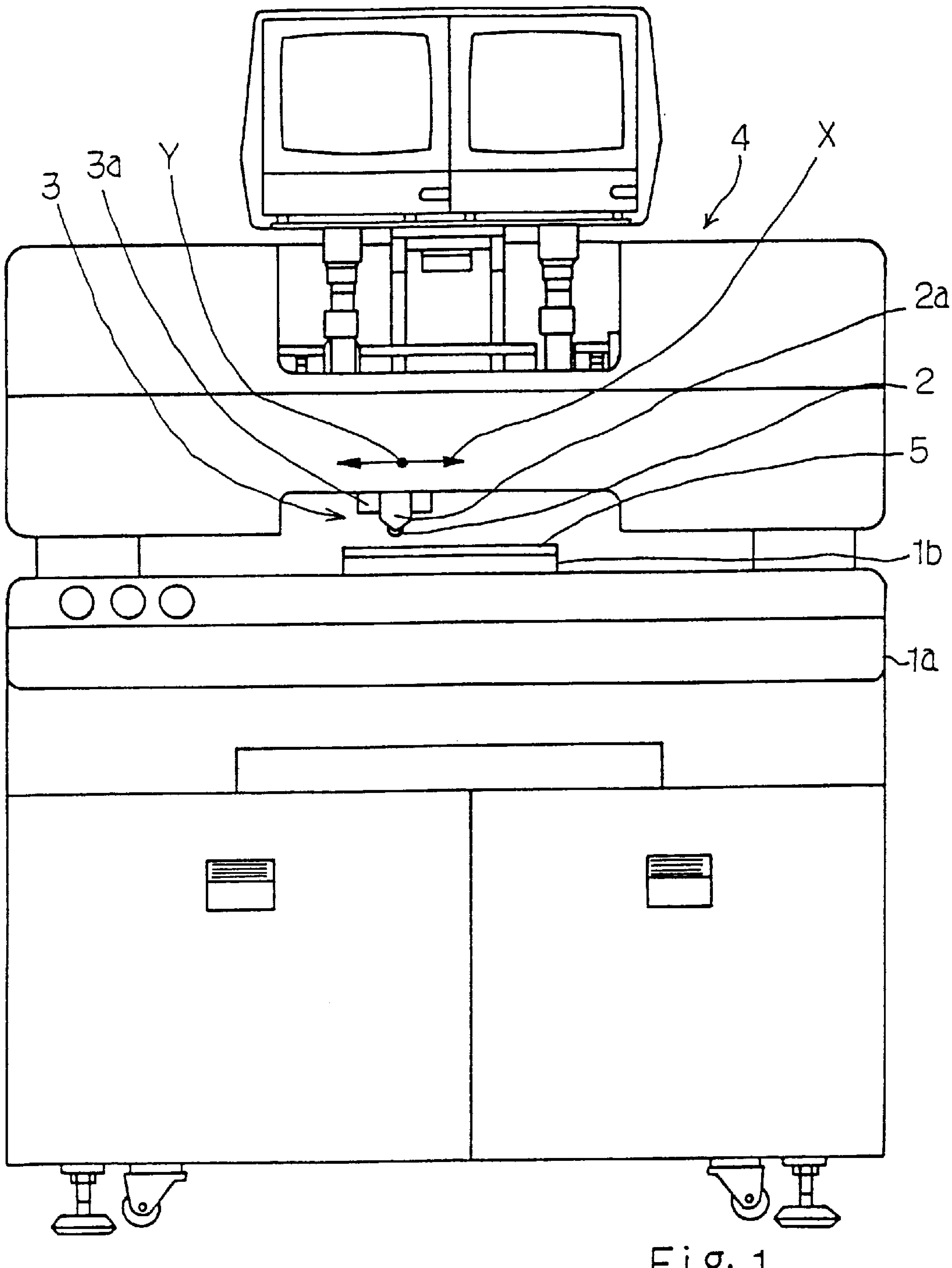


Fig. 1
PRIOR ART

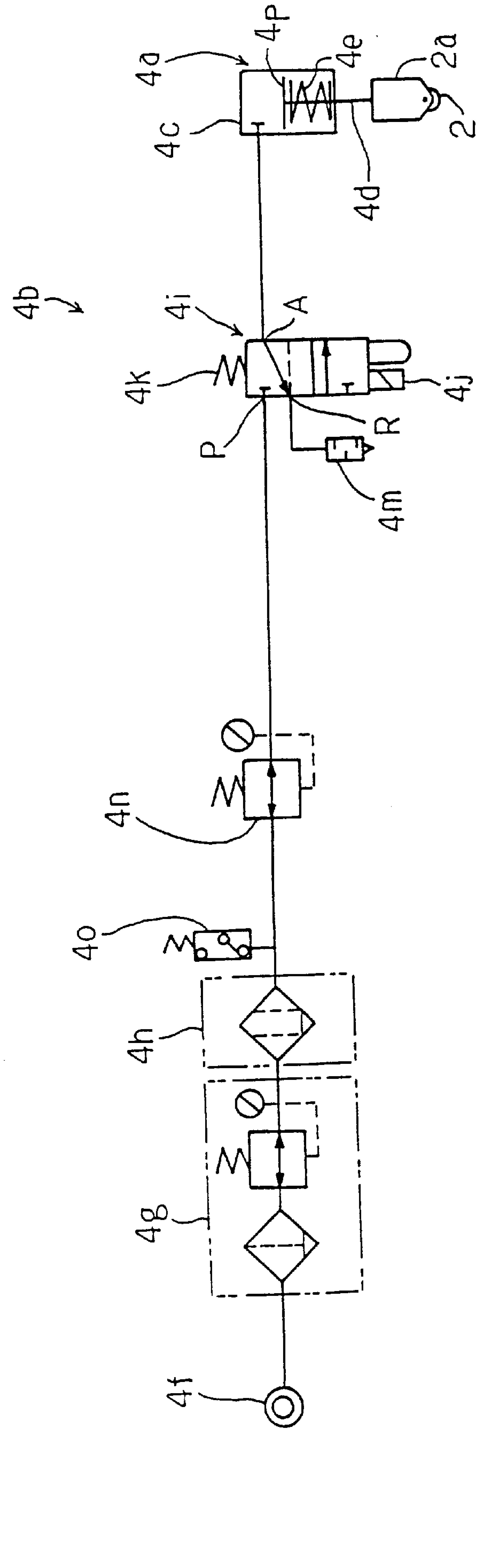


Fig. 2
PRIOR ART

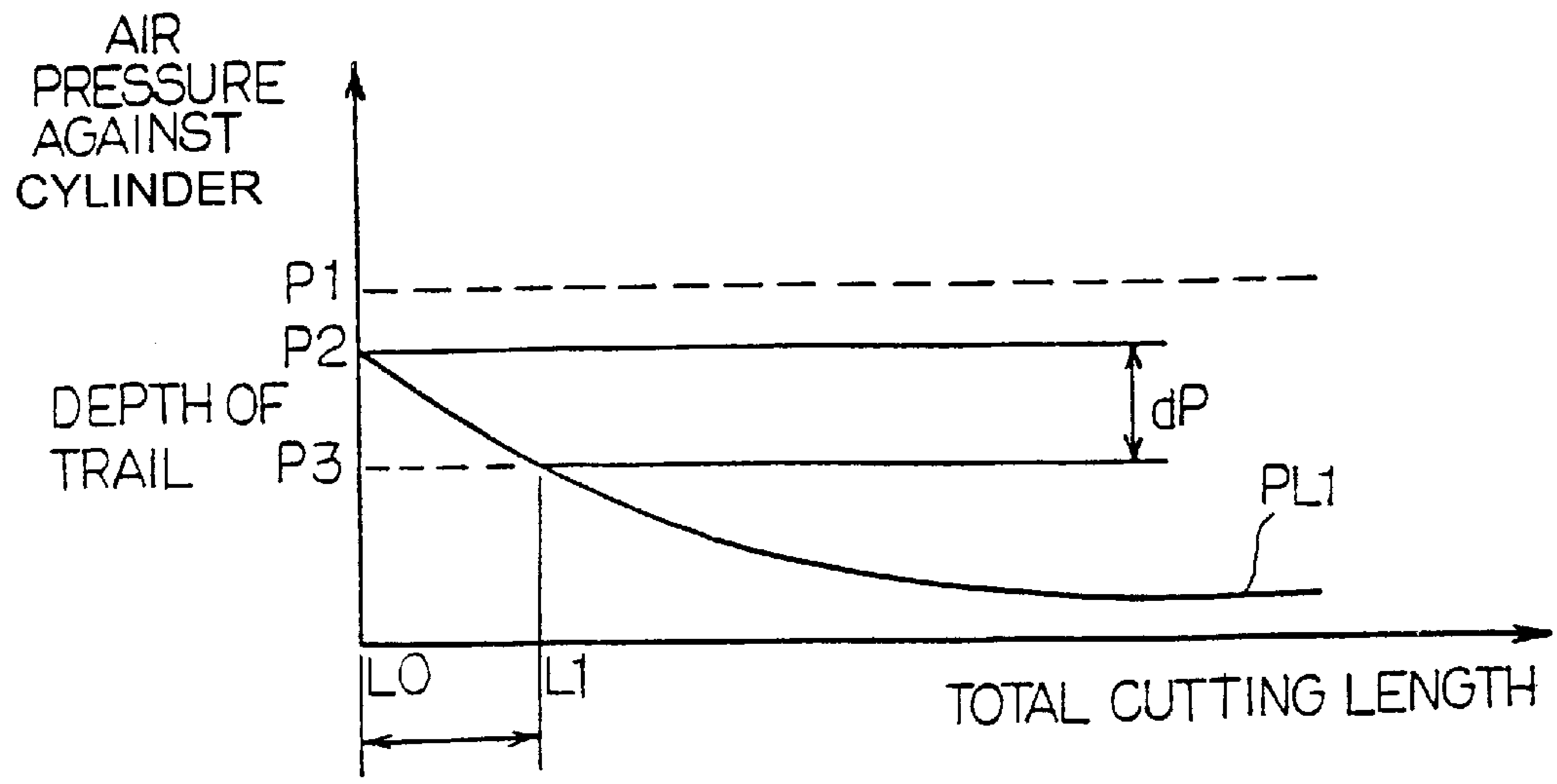


Fig. 3
PRIOR ART

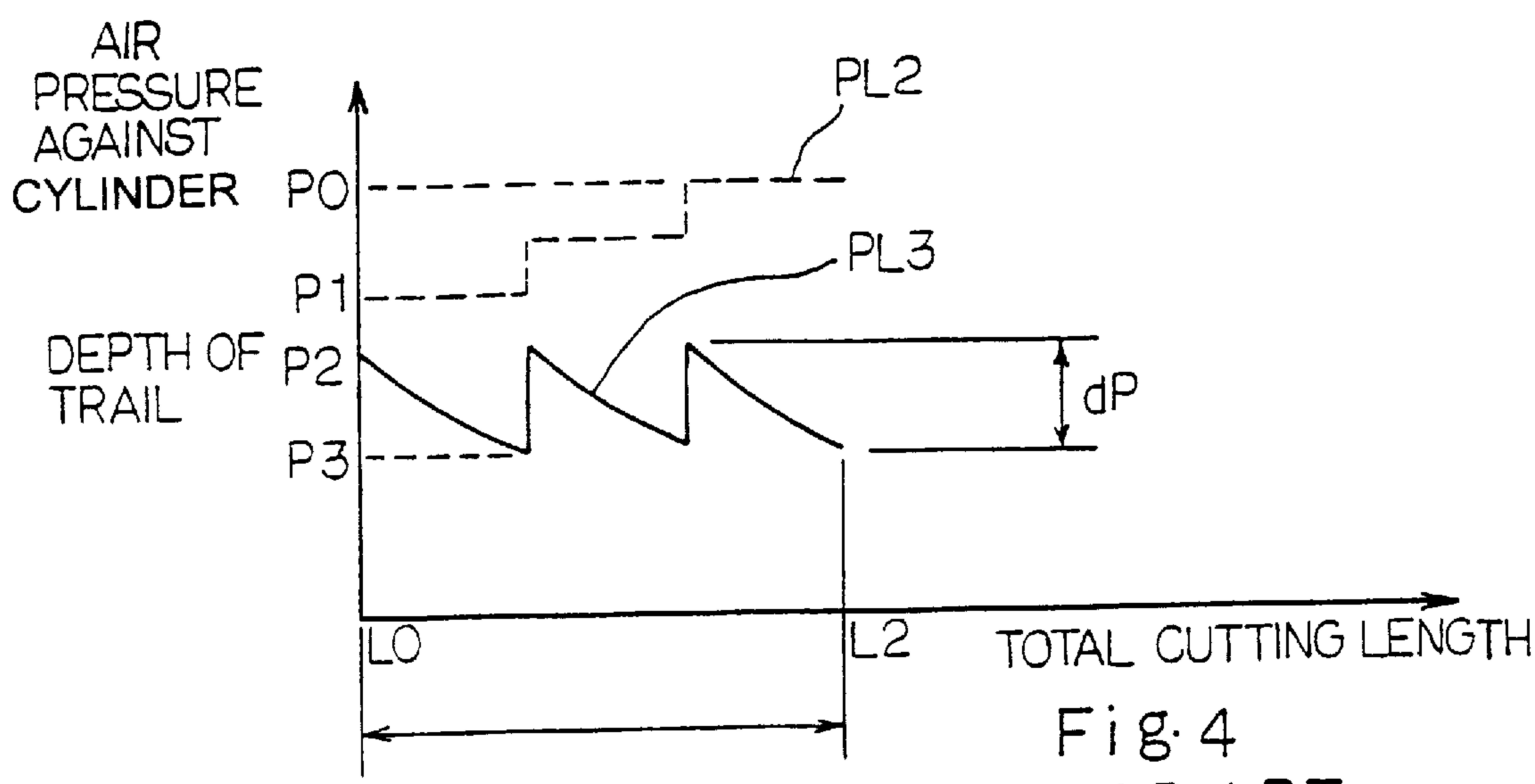


Fig. 4
PRIOR ART

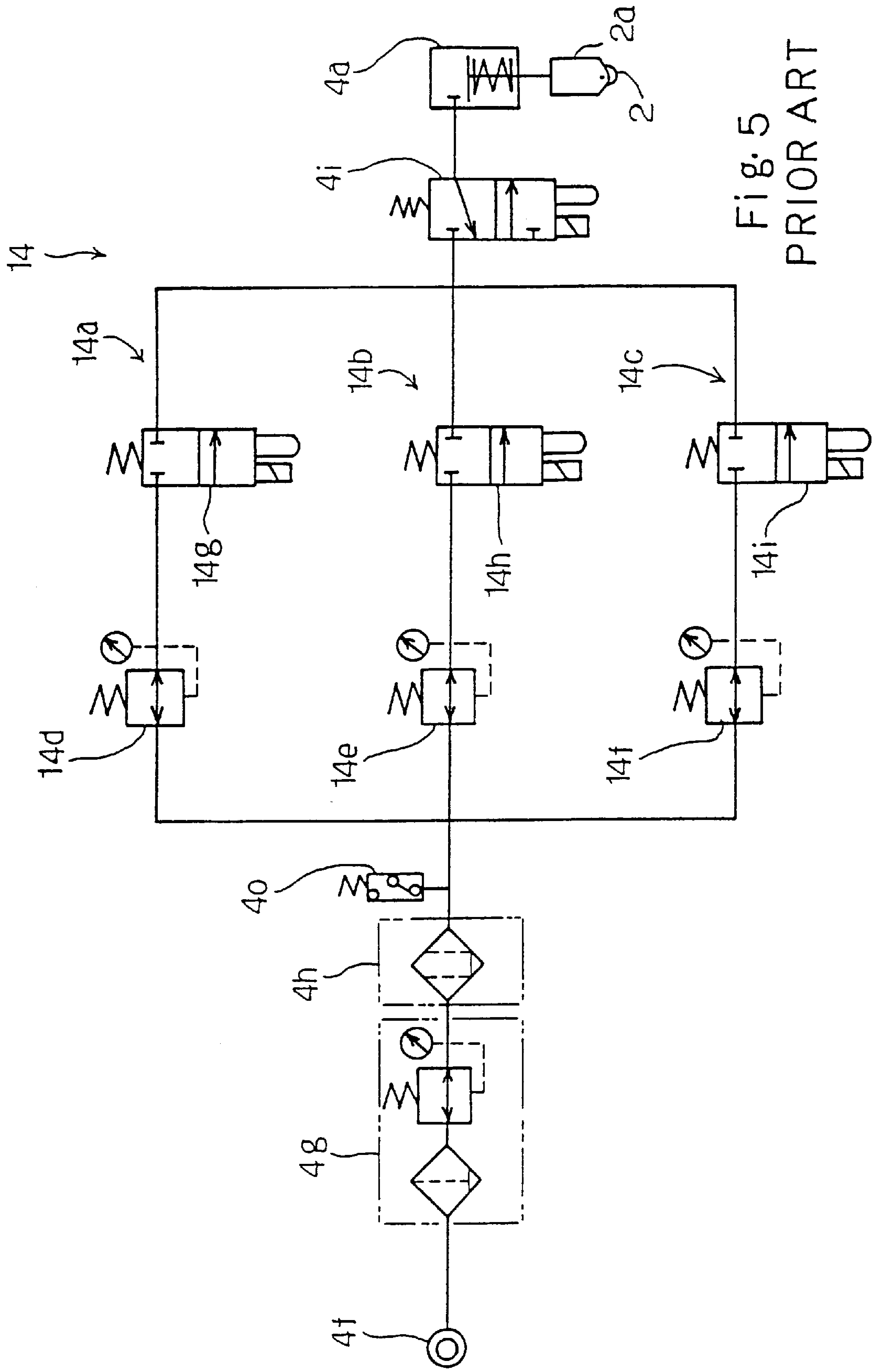


Fig. 5
PRIOR ART

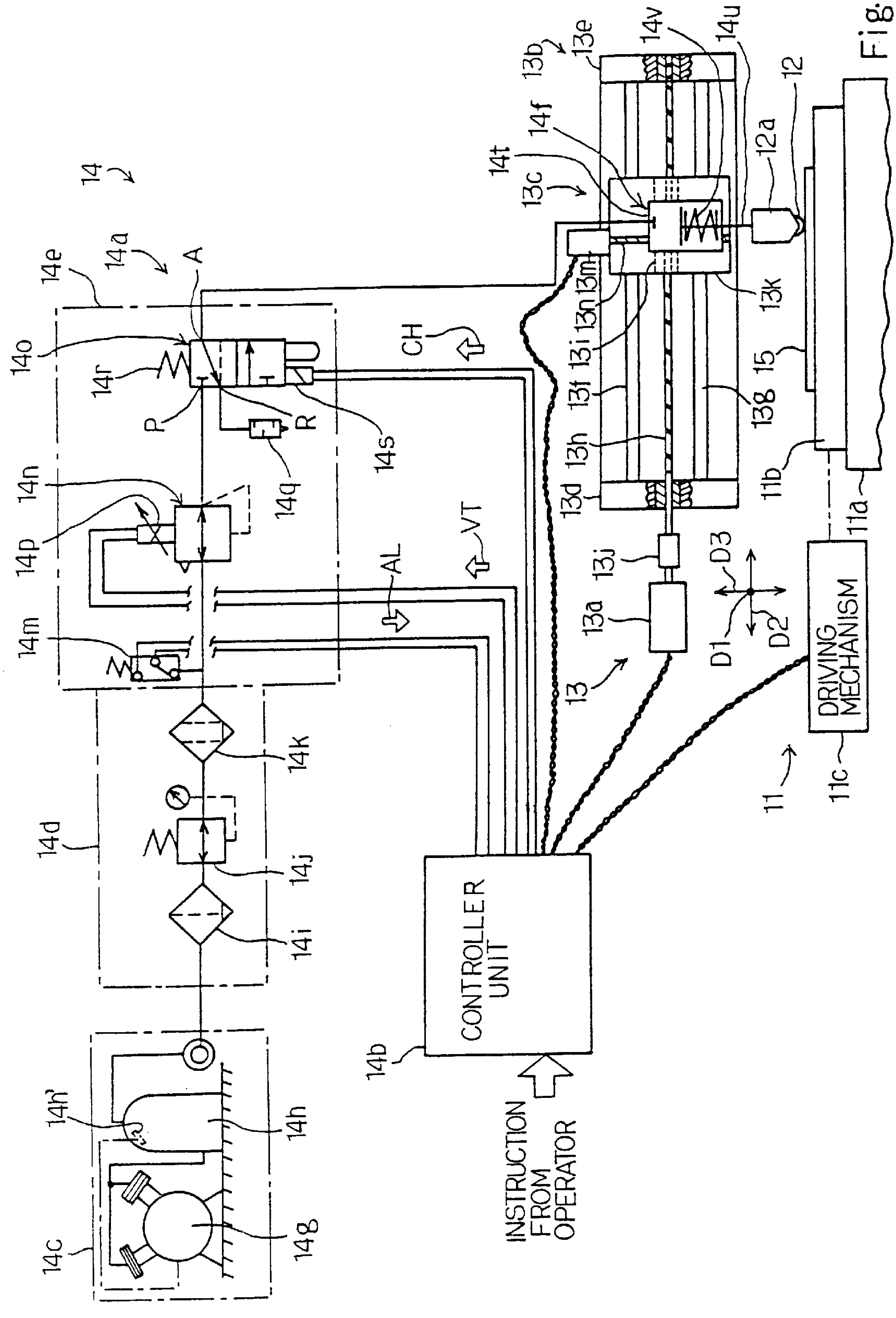

CONTROLLER UNIT
DRIVING MECHANISM
INSTRUCTION FROM OPERATOR
CH
VT
AL
A
P
R
D1
D2
D3
11
11a
11b
11c
12
12a
13
13a
13b
13c
13d
13e
13f
13g
13h
13i
13j
13k
13m
13n
14
14a
14b
14c
14d
14e
14f
14g
14h
14h'
14i
14j
14k
14m
14n
14o
14p
14q
14r
14s
14t
14u
14v
15

Fig.6

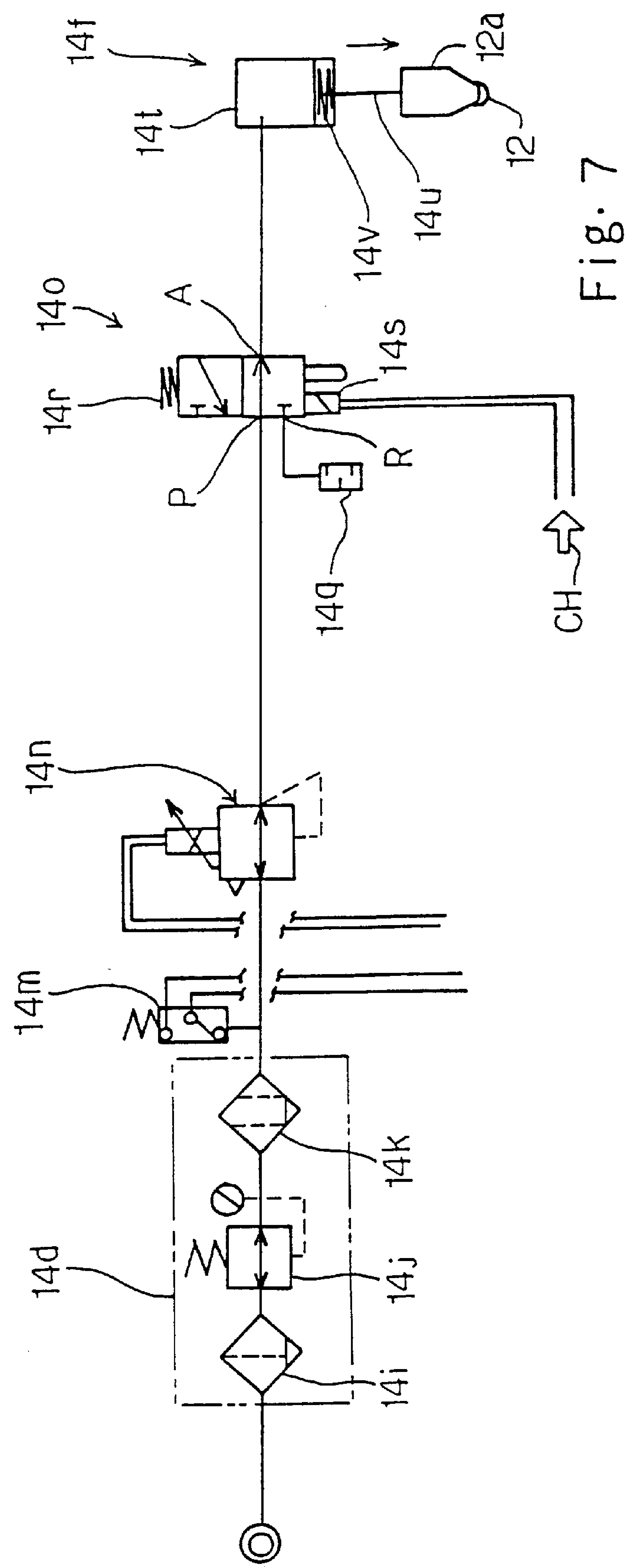

14f
12a
14t
12
14v
14u
14o
A
14r
14s
P
R
14q
CH
14n
14m
14d
14k
14j
14i

Fig. 7

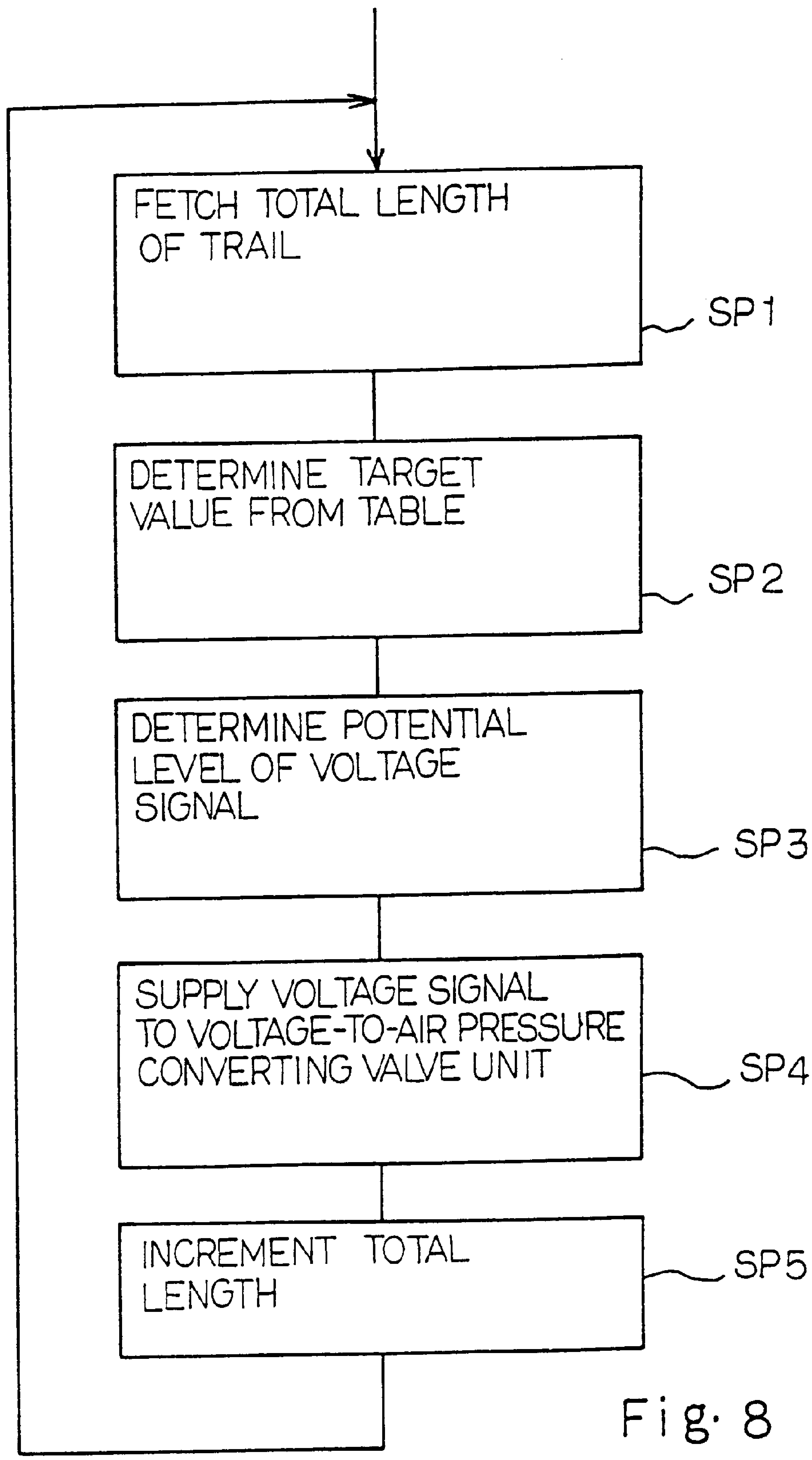

FETCH TOTAL LENGTH OF TRAIL
SP1
DETERMINE TARGET VALUE FROM TABLE
SP2
DETERMINE POTENTIAL LEVEL OF VOLTAGE SIGNAL
SP3
SUPPLY VOLTAGE SIGNAL TO VOLTAGE-TO-AIR PRESSURE CONVERTING VALVE UNIT
SP4
INCREMENT TOTAL LENGTH
SP5

Fig. 8

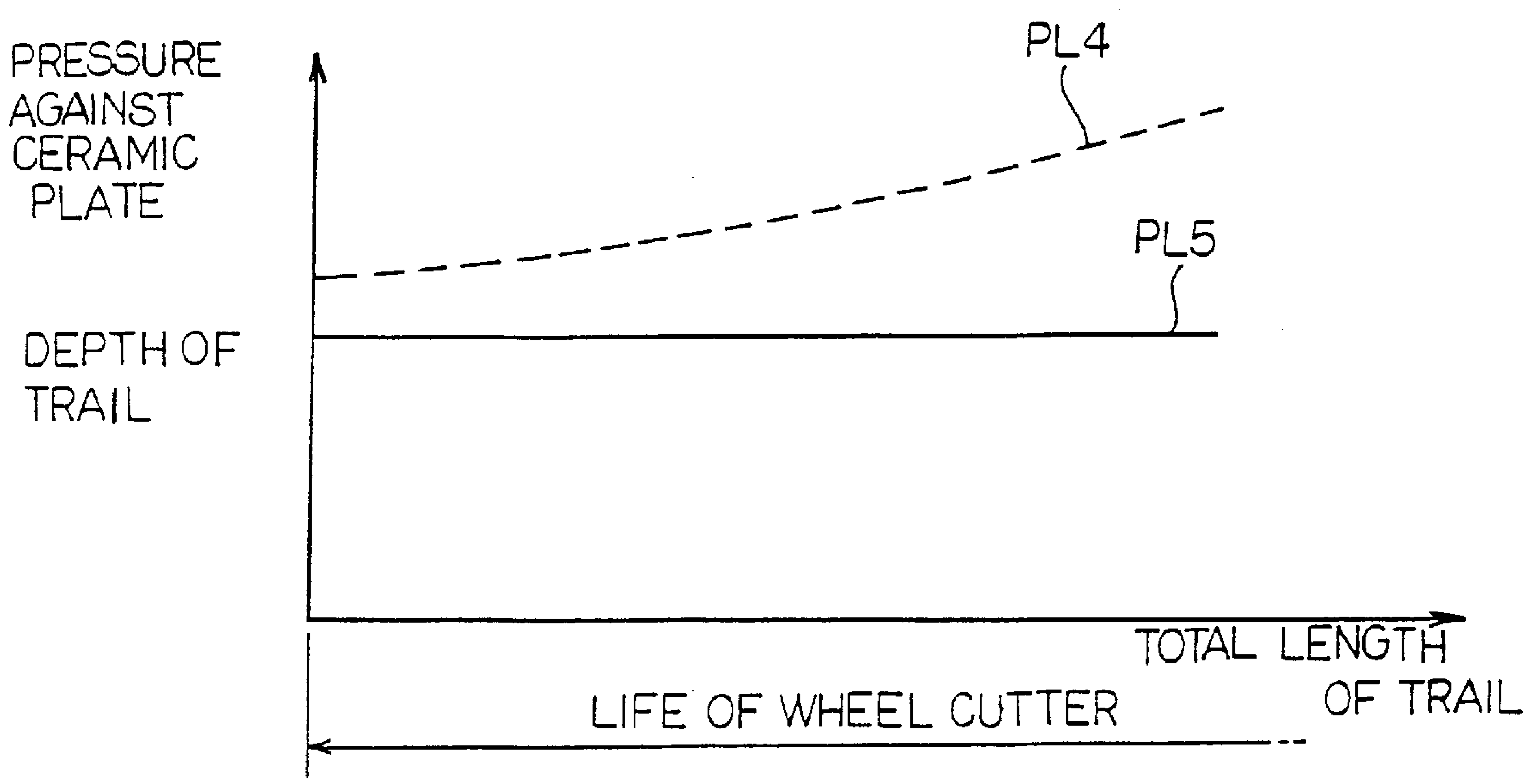

PRESSURE AGAINST CERAMIC PLATE
DEPTH OF TRAIL
PL4
PL5
TOTAL LENGTH OF TRAIL
LIFE OF WHEEL CUTTER

Fig. 9

CUTTING APPARATUS EQUIPPED WITH TOOL VARIABLY PRESSED AGAINST WORK DEPENDING UPON WORKING DISTANCE

RELATED APPLICATIONS

This is a division of application Ser. No. 08/878,480, filed Jun. 19, 1997, now U.S. Pat. No. 5,860,349 which is a continuation of application Ser. No. 08/524,047, filed on Sep. 6, 1995, now abandoned.

FIELD OF THE INVENTION

This invention relates to a cutting apparatus and, more particularly, to a cutting apparatus equipped with a cutting tool which is pressed against a brittle work of ceramic or glass with a variable pressure which is dependent upon running time of the cutting tool.

DESCRIPTION OF THE RELATED ART

A typical example of a cutting apparatus or "scriber" for cutting a workpiece such as a glass plate and a ceramic plate is shown in FIG. **1**. The prior art scriber largely comprises a working table structure **1**, a cutter wheel **2**, a driving system **3** for the cutter wheel **2** and a controlling system **4** for the driving system **3**.

The working table structure **1** includes a rigid base **1***a*, a movable table **1***b* movable in the Y-direction with respect to the rigid base **1***a* and a driving mechanism (not shown) for moving the movable table **1***b* under the control of the controlling system **4**. A ceramic plate workpiece **5** is mounted on the movable table **1***b*, and is moved together with the movable table **1***b* in the Y-direction.

The cutter wheel **2** is supported by a suitable retainer **2***a*, and the retainer **2***a* is functionally connected to the driving system **3**. The driving system **3** includes a slider **3***a* and a servo-motor (not shown), and moves the retainer **2***a* and, accordingly, the cutter wheel **2** in the X-direction with respect to the rigid base **1***a*.

As shown in FIG. **2**, the controlling system **4** includes a pusher or cylinder **4***a* provided for the retainer **2***a* and a pneumatic control sub-system **4***b*. A cylinder **4***c*, a plunger **4***d* movable in the cylinder **4***c* and a return spring **4***e* form in combination the pusher **4***a*. The retainer **2***a* is connected to the leading end of the plunger **4***d*. The plunger **4***d* is bi-stable, and projects from and retracts into the cylinder **4***c*.

The pneumatic control sub-system **4***b* is connected to a high-pressure air source **4***f*, and includes a combination unit **4***g* of air filter and pressure regulator, a separator **4***h* and a solenoid-operated three-port valve **4***i*. The three ports are labeled with "P", "A", and "R", and the solenoid **4***j* and a return spring **4***k* change the connection between the three ports "P", "A" and "R". The high-pressure air is supplied to the inlet port "P", and the outlet port "A" is connected to the cylinder **4***c*. The port "R" is open through a silencer **4***m* to the air.

When current is not supplied to the solenoid **4***j*, the return spring **4***k* connects the outlet port "A" to the port "R", and the solenoid-operated three-port control valve **4***i* discharges the high-pressure air from the cylinder **4***c* through the silencer **4***m* to the air. The plunger **4***d* retracts into the cylinder **4***c*, and the retainer **2***a* and, accordingly, cutter wheel **2** are spaced from the ceramic plate **5**.

On the other hand, when a controller (not shown) energizes the solenoid **4***j*, the electromagnetic force changes the connection from port "A"-to-port "R" to port "P"-to-port "A". Then, the high-pressure air is supplied to the cylinder **4***c*, and the plunger **4***d* projects from the cylinder **4***c*. The cutter wheel **2** is pressed against the ceramic plate **5**.

The pneumatic control sub-system **4***b* further includes a manually-operated pressure reducer **4***n* for regulating the high pressure air to an appropriate value and a pressure switch **4***o* for monitoring the air pressure. When an operator manipulates the pressure reducer **4***n*, the manually-operated pressure reducer **4***n* regulates the high-pressure air to a new value, and the pressure applied to the plate **4***p* of the cylinder **4***a* is changed depending upon the regulated air pressure. Since the force that the cutter wheel **2** applies to the ceramic plate **5** is a direct function of the pressure applied to the plate **4***p*, the force applied to the ceramic plate also increases proportionately.

When the air pressure is unintentionally decreased below a critical value due to, for example, air source failure, the pressure switch **4***o* supplies an alarm signal to the controller (not shown), and the controller informs an operator of an emergency state.

The prior art scriber thus arranged encounters a problem in that the cut surface of the ceramic plate **5** deteriorates with running time of the cutter wheel **2**. The reason for the deterioration is derived from the abrasion of the wheel cutter **2**. More specifically, while the wheel cutter **2** is cutting a ceramic plate, the trail of the wheel cutter **2** is getting shallower and shallower by increasing the total cutting length as shown in FIG. **3**. The high pressure air in the cylinder **4***c* is constant at P1, and the depth of the trail is proportional to the pressure against the ceramic plates. The pressure against the ceramic plate and, accordingly, the depth of the trail are decreased by increasing the running time or the total length cut by wheel cutter **2** as indicated by Plots PL1. Thus, the depth of the cutter wheel **2**. Particularly, while the cutter wheel **2** is cutting a ceramic plate, the depth of the groove cut by the cutter wheel **2** becomes more and more shallow as the total cutting length cut by the cutter wheel **2** increases as shown in FIG. **3**. A groove may extend part way into the workpiece or may cut all the way through the workpiece. The high pressure air in the cylinder **4***c* is at a constant pressure **P1**, and the depth of the groove cut by the cutter wheel **2** is proportional to the force applied by the cutter wheel **2** to the ceramic plate **5**. The force applied to the ceramic plate **5** and, accordingly, the depth of the groove cut by the cutter wheel **2** are decreased as a function of the running time or the total length cut by the cutter wheel **2** as indicated by Plot **PL1**. Thus, the depth of the groove cut by the cutter wheel **2** is decreased, and the cutting surface is deteriorated.

Of course, if the cutter wheel **2** is replaced with a new cutter wheel upon reaching the limit **P3** of the allowable depth range dP, the cutting surface is good. However, the running hours of the cutter wheel cutter **2** is short, and, accordingly, the frequent replacement increases the running cost of the prior art cutting apparatus.

In order to improve the cutting surface without sacrifice of the running cost, an operator may step-wise increase the air pressure on plate **4***p* from **P1** to **P0** as indicated by Plot **PL2** in FIG. **4**. The depth of the groove cut by cutter wheel **2** is prolonged to L2. However, the operator is expected to periodically check the depth of the groove cut by cutter wheel **2** and exactly regulate the air pressure. This monitoring work is not easy, and the operator sometimes forgets to check. This results in unexpected deterioration of the cutting surface.

Another prior art cutting apparatus is equipped with a pneumatic control sub-system **14** shown in FIG. **5**. The pneumatic control sub-system **14** has three paths **14**a, **14**b and **14**c arranged in parallel between the pressure switch **4**o and the solenoid-operated three-port control valve **4**i. However, the other components are similar to the prior art pneumatic control sub-system **4**b shown in FIG. **2**.

The three paths **14**a, **14**b and **14**c have respective pressure reducers **14**d, **14**e and **14**f and respective solenoid-operated two-port control valves **14**g, **14**h and **14**i, and the pressure reducers **14**d, **14**e and **14**f are regulated to different values between **P1** and **P0**. The solenoid-operated two-port control valves **14**g, **14**h and **14**i are electrically connected to the controller (not shown), and one of the solenoid-operated two-port control valves **14**g, **14**h and **14**i couples the associated pressure reducer to the solenoid-operated three-port control valve **4**i.

The controller selectively energizes the solenoids of the two-port control valves **14**g, **14**h and **14**i, and increases the air pressure supplied to the solenoid-operated three-port control valve **4**i. Then, the depth of the groove cut by the cutter wheel **2** traces plot PL**3** without the manipulation of the pressure regulator by an operator. However, the pneumatic control sub-system **14** is complicated, and the installation cost is high. Moreover, the pressure reducers **14**d, **14**e and **14**f are the manually-operated type, and the operator is expected to exactly set the pressure reducers **14**d, **14**e and **14**f to appropriate values. The manual regulation is necessary for different ceramic plates, and the operator sometimes forgets it.

SUMMARY OF THE INVENTION

It is therefore an important object of the present invention to provide a cutting apparatus which is simple in construction and low in running/installation costs.

To accomplish the object, the present invention automatically varies the pressure against a work piece as a function of the total cutting length of grooves formed in one or more workpieces by a single tool.

In accordance with the present invention, there is provided a cutting apparatus for cutting a work, comprising: a tool provided for the work; a pressing unit for pressing the tool against the work at a pressure; a driving unit causing relative motion between the tool and the work for producing movement of the tool relative to the work; a measuring unit for measuring the length of the movement of the tool across the work; and a controller for increasing the pressure as a function of the length of movement of the tool across the work.

BRIEF DESCRIPTION OF THE DRAWINGS

The features and advantages of the cutting apparatus according to the present invention will be more clearly understood from the following description taken in conjunction with the accompanying drawings in which:

FIG. **1** is a front view showing the prior art scriber;

FIG. **2** is a block diagram showing the pneumatic subsystem incorporated in the prior art scriber;

FIG. **3** is a graph showing the depth of the grooves formed in one or more workpieces by in terms of the total cutting length without regulation of the air pressure;

FIG. **4** is a graph showing the depth of the grooves formed in one or more workpieces by the cutter wheel in terms of the total cutting length under the regulation of the air pressure;

FIG. **5** is a block diagram showing the pneumatic control sub-system incorporated in the other prior art scriber;

FIG. **6** is a block diagram showing a cutting apparatus according to the present invention;

FIG. **7** is a block diagram showing a pneumatic control sub-system incorporated in the cutting apparatus;

FIG. **8** is a flow chart showing a control sequence for the cutting apparatus; and

FIG. **9** is a graph showing the depth of a groove formed in one or more workpieces by the cutter wheel in terms of the total cutting length under the control of a controlling system incorporated in the cutting apparatus.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to FIG. **6** of the drawings, a cutting apparatus embodying the present invention largely comprises a working table structure **11**, a cutter wheel **12**, a driving system **13** for the cutter wheel **2** and a controller system **14**.

The working table structure **11** includes a stationary rigid bed **11**a, a movable table **11**b movable in a direction D1 with respect to the stationary rigid bed **11**a and a driving mechanism **11**c for moving the movable table **11**b. The combination of an electric motor, a reduction gear unit and a pinion/rack may form the driving mechanism **11**c. The direction D1 is perpendicular to the plane of the paper of FIG. **6** and to directions D2 and D3.

The cutter wheel **12** is supported by a retainer **12**a, and is freely driven for rotation around an axis (not shown). The cutter wheel **12** is a sintered product of artificial diamond powder. The retainer **12**a and, accordingly, the cutter wheel **12** are associated with the driving system **13**, and are moved in the direction D3 and D2, respectively.

The driving system **13** includes a servo-motor unit **13**a, a stationary frame structure **13**b and a rotation-to-linear motion converting mechanism **13**c.

The stationary frame structure **13**b is provided over the working table structure **11**, and is constituted by bracket members **13**d and **13**e and two guide rods **13**f and **13**g. The bracket members **13**d and **13**e are spaced apart from each other by a distance not shorter than the length of the movable table **11**b, and the guide rods **13**f and **13**g extend in parallel between the bracket members **13**d and **13**e.

A ball thread unit serves as the rotation-to-linear motion converting mechanism **13**c. Namely, a male screw rod **13**h, a female screw block **13**i and balls (not shown) form the ball thread unit, and the male screw rod **13**h is assembled with the female screw block **13**i in in-phase manner. Though not shown in the drawings, the balls are inserted into the spiral gap between the male screw rod **13**h and the female screw block **13**i, and are circulated in the spiral gap. The male screw rod **13**h is rotatably supported by the two bracket members **13**d and **13**e, and is connected to the shaft of the servo-motor unit **13**a by means of a suitable coupling unit **13**j. A movable bracket **13**k is fixed to the female screw block **13**i, and is slidable on the guide rods **13**f and **13**g in the direction D2.

While the servo-motor unit **13**a is bi-directionally rotating the male screw rod **13**h in one direction, the movable bracket **13**k slides on the guide rods **13**f and **13**g toward the bracket **13**d and vice versa.

The driving system **13** further includes an electric motor unit **13**m and a rotation-to-linear motion converting unit **13**n provided between the electric motor unit **13**m and a cylinder **14**t supported by the movable bracket **13**k. The rotation-to-linear motion converting unit **13**n is similar to the ball thread unit comprising screw rod **13**h and screw block **13**i and no further description is incorporated hereinbelow for to avoid repetition.

While the electric motor unit **13***m* is rotating, the cylinder **14***t* is moved in the direction D**3**, and presses the cutter wheel **12** against or spaces it from a workpiece (ceramic plate **15**) located on the movable table **11***b*.

The controller system **14** includes a pneumatic control sub-system **14***a* serving as a controller and controller unit **14***b*, and the controller unit **14***b* directly controls the driving mechanism **11***c*, the rotation-to-linear motion converting mechanisms **13***c*, **13***n* and the pneumatic control sub-system **14***a* through data processing. More specifically, though not shown in the drawings, a data processor, a program storage, a data storage and a signal interface are incorporated in the controller unit **14***b*, and the data processor executes instructions supplied from the program storage as will be described in detail in conjunction with a cutting operation on the ceramic plate **15**.

The pneumatic control sub-system **14***a* (i.e., controller) includes a high pressure air source section **14***c*, a pretreatment section **14***d*, a controller section **14***e* and an actuator **14***f*. An air compressor unit **14***g* and a reservoir tank **14***h* form in combination the high pressure air source section **14***c*, and supplies high-pressure air to the pretreatment section **14***d*. When the air pressure in the reservoir tank **14***h* reaches an upper limit, the air compressor unit **14***g* interrupts the air compressing. However, if the air pressure in the reservoir tank **14***h* is lowered to a lower limit, a pressure switch **14***h*' detects the low pressure, and instructs the air compressor unit **14***g* to restart the operation. Thus, the high-pressure air source section **14***c* supplies the high-pressure air between the higher limit and the lower limit to the pre-treatment section **14***d*.

The pretreatment section **14***d* contains an air filter **14***i*, an air pressure regulator **14***j* and a separator **14***k*. The air filter **14***i* eliminates dust from the high-pressure air, and the air pressure regulator **14***j* keeps the air pressure constant.

The controller section **14***e* contains a pressure switch unit **14***m*, a voltage-to-air pressure converting valve unit **14***n* and a solenoid-operated three-port control valve unit **14***o*. The pressure switch unit **14***m* monitors the high-pressure air supplied from the pretreatment unit **14***d*, and generates an alarm signal AL which indicates that the actual air pressure is lower than a critical level. The alarm signal AL is supplied to the controller unit **14***b*.

The voltage-to-air pressure converting valve unit **14***n* is responsive to a potential signal (a control signal) VT indicative of a target value of the high-pressure air so as to cause the actual air pressure to reach the target value. A solenoid **14***p* is incorporated in the voltage-to-air pressure converting valve unit **14***n*, and generates electromagnetic force in the presence of the potential signal VT. The electromagnetic force is variable with the voltage level of the potential signal VT, and changes a throttle (not shown) for changing the air pressure at the outlet port thereof. The throttle is further controlled in such a manner as to keep the air pressure to the target value regardless of the amount of air flow. The potential signal VT is step-wise variable, and, accordingly, the voltage-to-air pressure converting valve unit **14***n* can step-wise vary the actual air pressure. In an actual control, the step of the potential variation is so narrow that the voltage-to-air pressure converting valve unit increases the air pressure as if it traces a linear line.

The solenoid-operated three-port control valve unit **14***o* has an inlet port P, an outlet port A and discharge port R. The inlet port R is connected to the outlet port of the voltage-to-air pressure converting valve unit **14***n*, and the outlet port A is connected to the actuator **14***f*. The discharge port R is open through a silencer **14***q* to the air. The solenoid-operated three-port control valve unit **14***o* is bi-stable. Namely, a return spring **14***r* causes the outlet port A to be connected to the discharge port R in the absence of a change-over control signal CH supplied form the controlling unit **14***b*. However, when the change-over control signal CH is supplied to a solenoid **14***s*, the inlet port P is connected to the outlet port A, and the high-pressure air is transferred from the voltage-to-air pressure converting valve unit **14***n* to the actuator **14***f*.

The cylinder **14***t*, a plunger **14***u* and a return spring **14***v* constitute the actuator **14***f*. The outlet port A is connected to the cylinder **14***t*, and supplies the high-pressure air to the inner chamber of the cylinder **14***t*. The plunger **14***u* is slidably accommodated in the inner chamber of the cylinder **14***t*, and the retainer **12***a* is connected to the leading end of the plunger **14***u*. The plunger **14***u* is urged by the return spring **14***v*, and projects from and retracts into the inner chamber depending upon the pressure in the inner chamber of the cylinder **14***t*.

The retainer **12***a* is moved together with the plunger **14***u* in the direction D**3**, and the cutter wheel **12** is pressed against or spaced from a ceramic plate **15** mounted on the movable table **11***b*.

In this instance, the cutter wheel **12** supported by the retainer **12***a* serves as a tool, and the cylinder **14***t* behaves as the pressing unit. The servo-motor **13***a*, the stationary frame structure **13***b*, the rotation-to-linear motion converting unit **13***c* and the couping unit **13***j* as a whole constitute a driving unit. The high-pressure source section **14***c*, the pre-treatment section **14***d*, and the controller section **14***e* and the controller unit **14***b* form in combination a controller, and a measuring unit, which is a data processing unit, is implemented by the controller unit **14***b* as will be understood hereinbelow.

Assuming now an operator fixes the ceramic plate **15** to the movable table **11***b*, the driving mechanism **11***c* aligns the cutter wheel **12** with an imaginary cutting line on the ceramic plate **15**. The controller unit **14***b* instructs the servo-motor unit **13***a* to move the bracket **13***k* to a starting point over the right of the ceramic plate **15**. Although the air compressor unit **14***g* has stored the high-pressure air in the reservoir tank **14***h*, the controller unit **14***b* does not supply the change-over control signal CH to the solenoid **14***s*, and the solenoid-operated three-port control valve unit **14***o* conducts the atmospheric pressure to the inner chamber of the cylinder **14***f*. For this reason, the return spring **14***v* causes the plunger **14***u* to retract into the inner chamber, and the wheel cutter **12** is spaced from the ceramic plate.

When the operator instructs the controller unit **14***b* to start the cutting operation on the ceramic plate **15**, the controller unit **14***b* minimizes the potential level of the potential signal VT, and instructs the voltage-to-air pressure converting valve unit **14***n* to regulate the actual air pressure to the minimum target value.

Subsequently, the controller unit **14***b* supplies the change-over control signal CH to the solenoid **14***s*, and the solenoid-operated three-port control valve unit **14**_o_ connects the inlet port P to the outlet port A as shown in FIG. **7**. Then, the high-pressure air is supplied through the solenoid-operated three-port control valve unit **14**_o_ to the inner chamber of the cylinder **14**_t_. The plunger **14**_u_ projects from the cylinder **14**_t_, and presses the cutter wheel **12** against the right end of the cutting line on the ceramic plate **15** at the minimum pressure.

The controller unit **14**_b_ instructs the three servo-motor unit **13**_a_ to rotates the male screw rod **13**_h_. The rotation-to-linear motion converting unit **13**_c_ moves the movable bracket **13**_k_ and, accordingly, the actuator **14**_f_ and the cutter wheel **12** along the cutting line toward the left end of the ceramic plate **15**. The cutter wheel **12** cuts the ceramic plate along the cutting line, and a groove is cut in the ceramic plate **15**.

When the wheel cutter **12** reaches the left end on the cutting line, the controller unit **14**_b_ instructs the serve-motor unit **13**_a_ to stop the rotation, and the movable bracket **13**_k_ and the cutter wheel **12** terminate at the left end on the cutting line. The controlling unit **14**_b_ removes the change-over control signal CH from the solenoid **14**_s_. Then, the cutter wheel **12** stops the rotation, and the return spring **14**_r_ causes the outlet port A to the discharge port R to be conducted. Then, the high-pressure air is discharged from the inner chamber of the cylinder **14**_t_ through the solenoid-operated three-port control valve unit **14**_o_ and the silencer **14**_q_ to the atmosphere.

The return spring **14**_v_ causes the plunger **14**_u_ to retract into the cylinder, and the cutter wheel **12** is spaced from the ceramic plate **15**.

Thus, the cutting apparatus repeats the cutting operation on ceramic plates **15**.

When the cutter wheel **12** is replaced with a new one, the data processor resets an internal register of the data storage to zero. While the cutter wheel **12** is cutting along the cutting line, the data processor increments (keeps track of) the total length of the trail (the groove(s) cut by cutter wheel **12**), and checks the total length of the trail to determine the potential level of the voltage signal VT.

In detail, the data processor executes a main routine program, and controls the driving mechanism **11**_c_, the driving system **13** and the controller system **14** for cutting or scribing the ceramic plate **15**. In order to control the controller system, the data processor repeats a routine shown in FIG. **8** during the cutting operation. First, the data processor fetches the data indicative of the total length of the trail stored in the internal register in (as by) step SP**1**, and compares the total length of the trail with a table defining the relationship between the total length of the trail applied to the cylinder **14** and the target value of the high-pressure air. The table is stored in the data storage device. The table divides the length of the trail into narrow ranges, and associates the narrow ranges with different target values, respectively. However, the target value varies as if it traces a linear line as described hereinbefore.

The data processor determines the target value through the comparison with the table in step SP**2**, and instructs a signal generator to regulate the voltage signal VT to the potential level indicative of the target value in step SP**3**.

The data processor allows the signal generator to supply the voltage signal VT to the voltage-to-air pressure converting valve unit **14**_n_ in step SP**4**, and increments the total length of the trail in step SP**5**.

Thus, the data processing unit reiterates the loop consisting of steps SP**1** to SP**5** until the service life of the wheel cutter **12** is expired.

The total length of the trail is measured as follows. If a numerical control is employed, the data processing unit calculates the total length on the basis of the control data for the numerical control.

If the cutting line is constant, the data processing unit multiplies the length of the cutting line by the number of repetition so as to determine the total length of the trail.

A revolution meter such as an encoder plate is fixed to the shaft supporting the wheel cutter **12**, and the number of the rotations is reported to the data processing unit. The data processing unit multiplies the circumferences of the wheel cutter by the number of rotations so as to determine the total length of the trail.

Thus, the controlling unit **14**_b_ renews the total length of the trail, and varies the target value of the high-pressure air. As a result, the air pressure, and therefore the force of the cutter wheel **12** against the ceramic plate **15**, is increased as a function of the length of the trail as indicated by plot PL**4**, and the depth of the trail is maintained at constant as indicated by plot PL**5** (see FIG. **9**). This results in a constant cutting surface, and prolongs the life of the wheel cutter **12**. Moreover, the controlling unit **14**_b_ changes the target value for the high-pressure air, and the wheel cutter **12** is exactly controlled without an error.

While the cutting apparatus is carrying out the cutting operation on the ceramic plate **15**, the high-pressure air is assumed to become lower than the critical value, the pressure switch **14**_m_ produces the alarm signal AL, and supplies the alarm signal AL to the signal interface of the controlling unit **45**_b_. The controlling unit acknowledges the emergency state, and removes the change-over control signal CH from the solenoid **14**_s_. Then, the solenoid-operated three-port control valve **14**_o_ conducts the outlet port A to the discharge port R, and the high-pressure air is evacuated from the inner chamber of the cylinder **14**_t_ to the atmosphere. As a result, the return spring **14**_v_ causes the plunger **14**_u_ to retract into the cylinder **14**_t_, and the wheel cutter **12** is spaced form the ceramic plate **15**. The controlling unit **45**_b_ further instructs the servo-motor **13**_a_ to stop the rotation, and generate an alarm sign on a display (not shown).

Although particular embodiments of the present invention have been shown and described, it will be obvious to those skilled in the art that various changes and modification may be made without departing from the spirit and scope of the present invention.

For example, an electric circuit and a solenoid-operated actuator may be used instead of the pneumatic control sub-system **14**_a_ and the actuator **14**_f_.

Moreover, the driving mechanism may rotate the movable table so as to carry out a position control in a rotational coordinates. The wheel cutter may be replaced with a scriber, and may be rotated by a motor unit.

What is claimed is:

1. A process for cutting one or more grooves in a workpiece using a cutting tool wears as it cuts, said process comprising the steps of:

causing relative movement between said tool and said workpiece while pressing said tool against said workpiece to cause said tool to form one or more grooves in said workpiece;

generating a signal indicative of said total length of the one or more grooves which said tool forms in said workpiece;

processing said signal to determine an appropriate value of said pressure to be exerted on said workpiece; and

adjusting said pressure to said appropriate value at which said tool is pressed against said workpiece as a function of said total length indicated by said signal.

2. A process for cutting one or more grooves in a workpiece according to claim **1**, wherein said pressure is increased as said distance increases.

3. A process for cutting one or more grooves in a workpiece according to claim **2**, wherein said tool is a rotating cutter wheel.

4. A process for cutting one or more grooves in a workpiece according to claim **2**, wherein said tool is pressed against said workpiece by a pneumatic cylinder with a pressure determined by the pressure of a gas applied to said pneumatic cylinder and said step of adjusting said pressure comprises the step of adjusting the pressure of said gas applied to said pneumatic cylinder.

5. A process for cutting one or more grooves in one or more workpieces using a cutting tool that wears as it cuts, said process comprising the steps of:

causing relative movement between said tool and said one or more workpieces while pressing said tool against said one or more workpieces to cause said tool to form one or more grooves in said one or more workpieces;

generating a signal indicative of said total length of the one or more grooves which said tool forms in said one or more workpieces; processing said signal to determine an appropriate value of said pressure to be exerted on said one or more workpieces; and

adjusting said pressure to said appropriate value at which said tool is pressed against said one or more workpieces as a function of said total length indicated by said signal.

6. A process for cutting one or more grooves in one or more workpieces according to claim **5**, wherein said pressure is increased as said distance increases.

7. A process for cutting one or more grooves in one or more workpieces according to claim **5**, wherein said tool is a rotating cutter wheel.

8. A process for cutting one or more grooves in one or more workpieces according to claim **6**, wherein said tool is pressed against said one or more workpieces by a pneumatic cylinder with a pressure determined by the pressure of a gas applied to said pneumatic cylinder and said step of adjusting said pressure comprises the step of adjusting the pressure of a gas applied to said pneumatic cylinder.

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